The Optimization of High-Density Campus Transportation Based on Green Transport

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Abstract. With the increasing importance of the concept of sustainable development and environmental protection, green transportation has become one of the core ideas of modern transportation planning, but it is mainly applied to urban transportation rather than campus transportation. The travel characteristics of campus transportation are different from those of urban transportation, and high-density campuses with higher population density and building density are more in need of green transportation methods. The article takes the Xinzhuang campus of Nanjing Forestry University as an example, and investigates the campus in three aspects: spatial form, dynamic traffic and static traffic; by drawing on the neighborhood community model, emphasizing the status of slow traffic and adopting green technology, it proposes optimization methods such as dividing campus clusters, creating campus public space, optimizing road classification and cross-sectional form, supplementing public transport and compounding the layout of parking facilities to alleviate the paradox of traditional campus transport. The aim is to provide a healthy and safe travel environment for students and teachers, and to provide a reference for other high-density campuses in terms of traffic optimization.

Keywords: Green transport · Campus transport · High density campus

1 Introduction

It was a period of concentrated construction in American colleges and universities in 1960s. R.P. Dober specified the design requirements of roads and car parks on campus, and analyzed the planning of campus transportation systems from the perspective of landscape design science [1]. Chinese scholars have also summarized a design system in terms of planning, landscape and architecture for local campus [2]. These leads to a study of common problems such as the pedestrian environment [3], traffic safety [4], the adaptation of traditional campuses to new technologies [5], and a case study of a campus under special conditions [6], where most high-density studies targeting congested cities. In recent years many scholars have focused on this feature of high density on campus planning and design [7]. Most of them have focused on the design of the spatial form, with relatively little research on the campus road system. Green transport has been widely used in urban transport planning [8]. However, the circumstance is quite different in

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the campus transport. This study investigates the campus transport system, and then proposes optimization strategies based on the transport characteristics of high-density campuses with green transport as the guide, especially for the medical problem like takeaway, enriching the study of the transport system of high-density campuses.

2 Basic Concepts and Characteristics

2.1 Green Transport

Green transport requires to satisfy the travel needs while protecting the environment [9]. To implement this concept on campus, firstly, the proportion of slow transport should be increased; secondly, gas and noise pollution should be reduced; the road network on campus need to improve the accessibility [4].

2.2 High-Density Campus

In urban planning, the floor area ratio is often used as the primary indicator [10]. When this indicator is too high, the problems of static space tension, intersection traffic conflicts and high-intensity traffic flow will become more acute [7]. This will result in greater demands on the planning of a efficient transport system.

3 Analysis of Traffic Problems on High-Density Campuses

3.1 Rationale for Case Selection

The Xinzhuang campus of Nanjing Forestry University covers a relatively low area among many universities in Nanjing, and students generally report that the campus is crowded, which is one of the typical representatives of a high-density campus.

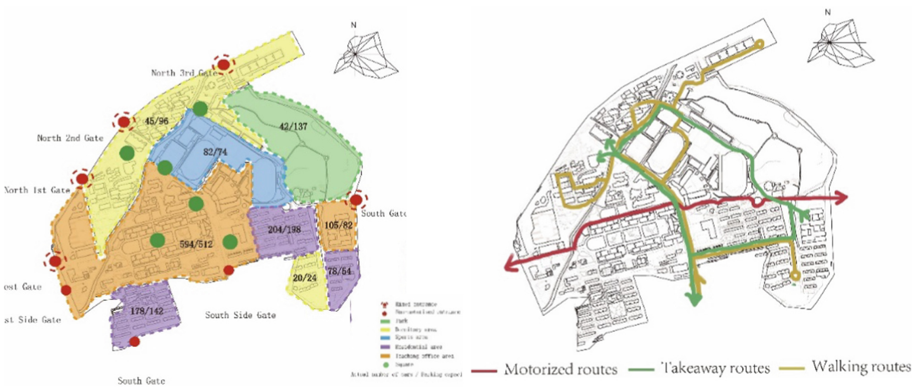

Fig. 1. Current space form, static traffic and traffic flow in peak hours.

3.2 Campus Space Form

Entrance. The main problems with the traffic at the entrances are: firstly, the width of the passage space at the entrances and exits is insufficient, many different traffic types compete with each other for the right of way; secondly, there is a lack of traffic space, cause it can only meet the needs to pass quickly, while being unable to stay. Thirdly, some entrances are unsupervised, causing traffic chaos (see Fig. 1).

Long Internal Commuting Distances. More added dormitory areas and teaching offices making what was once a clearer functional zoning more chaotic. The distance from the new buildings to the central living areas become larger, causing much unnecessary commuting traffic (see Fig. 1).

3.3 Campus Dynamic Traffic

Daily Travel Survey. Campus traffic is dominated by students, staff and social outsiders. Traffic activity on campus is strongly regular, with a surge in pedestrian and vehicular traffic during peak periods of the school day and in a single direction. Campus traffic consists of pedestrians, non-motorized vehicles and motorized vehicles, so it is necessary to overlay the traffic flow of both in order to better analyze the overall situation of campus traffic (see Fig. 1).

Takeaway Issues. Research shows that takeaways are delivered during peak meal times, and there will be a spike in delivery during snow and rain. Students' destinations after classes are similar to the deliveries. The massive flow of people and traffic to the same area simultaneously, coupled with the lack of road space, is a significant cause of traffic accidents caused by takeaway deliveries.

3.4 Campus Static Traffic

After field research, the existing motor vehicle parking spaces is 1319, and the number of legal parking spaces and the actual number of it were different (see Fig. 1). It shows that the parking pressure in the teaching office and residential areas are higher in comparison. Half of the staff reflected on the problems of on-street parking. There are lots of long-standing unused non-motorized vehicles that take up parking space.

4 Strategies for Optimizing High-Density Campus Traffic

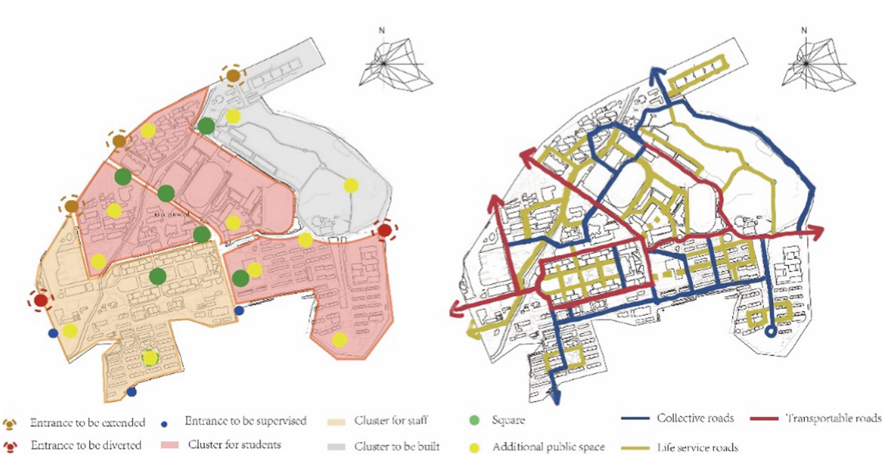

Fig. 2. Nanjing Forestry University Xinzhuang Campus traffic optimization plan.

4.1 Optimization of Space Form

Entrance. For the entrances for motor vehicles, the West Gate, which has a large traffic flow, should provide a special lane for pedestrian based on the separation of vehicles; in the East Gate, the buffer zone should be spared to form a small square cambinated with surrounding landscape, to improve its buffering capacity; for entrances focusing on non-motor vehicles, a more professional duty system is required (see Fig. 2).

Function. In 1920s New Urbanism hopes to reshape the atmosphere of urban planning, highlighting the humanity. TND abandoned mechanical functional zoning that ignores the diverse needs of the community, and calls for a compact and walkable neighborhood structure. Many educators believe that the university is a unique community, where students live on a specific size campus and form different campus cultures. That will be, therefore, suitable for student-centered high-density campuses.

Division of Campus Clusters. Using a composite functional cluster as an integrated functional cell of the campus, can avoid the inconvenience of dividing the campus into functional zonings, which leads to excessive distances between sub-zones. This method is more applicable to new campuses under construction. For old campuses the existing conditions can be fully utilized through the grouping pattern of some disciplines and the relative concentration of some campus spaces.

Creation of Dynamic Public Space. In addition to large squares, small squares, small green areas should be enlarged, and more building spaces should be opened up for various clusters. Then students will shorten the distance to have a meet, reducing the traffic load on the main roads. For outdoor spaces, the landscape of the campus can be fully utilized, or construct new public spaces; for indoor spaces, the connection between the ground floor space and the public space can be taken into account, which is called ‘shared ground floor’. The method gives up some of the building space, but adds to the vitality of the space and allows the crowded space to be fully utilized (see Fig. 2).

4.2 Optimization of Dynamic Traffic

Road Network. Within the campus, students’ needs for space to do activities is even more vital. Therefore, it is necessary to determine the traffic function as the primary function and ensure that the road is created to accommodate slow-moving traffic. This study classifies campus roads into transportable roads, collective roads and life service roads (see Fig. 2).

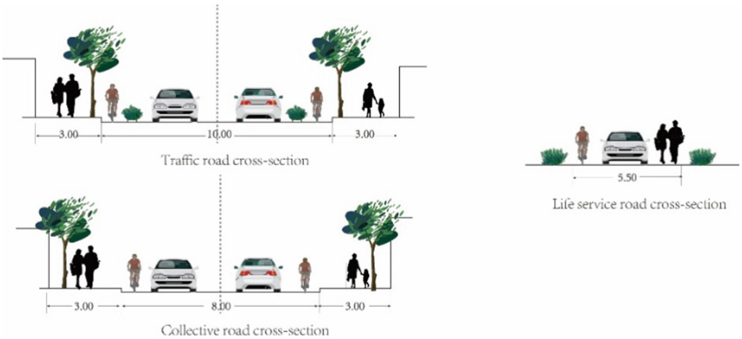

Fig. 3. Cross-section of three kinds of roads.

Transportable Roads. As the highest level of the entire campus road network, its function should be mainly motorized traffic, so that it should satisfy the two-way motor vehicle traffic, reduce the parking on both sides, weaken the slow traffic function. Green landscaping can be placed on both sides of the road, to reduce the negative impact of harmful gases and noise generated by cars (see Fig. 3).

Collective Roads. The collective road serves as a link between the campus center and the surrounding clusters. It needs to satisfy the demand of motor and slow traffic. Its road width still needs to meet the two-way motorized traffic, but also needs to increase the space for non-motorized vehicles and pedestrians(see Fig. 3).

Living Service Roads. It mainly serve short-distance traffic, penetrating into various groups and plots, and the emphasis should be on slow-moving traffic. The building complex will be the future of high-density campus architecture: buildings may run through the pedestrian corridor as a whole, allowing the pedestrian paths to leave the ground and integrate with the buildings. The pedestrianisation of high-density campuses should be combined with the ‘ground floor sharing’ of public spaces so that the pedestrian paths penetrate deeper into the building (see Fig. 3).

Road Refinement Design
Design for Traffic Stabilization. Currently, traditional campuses arrange speed bumps and installing turnouts in complex zones at intersections. It can be added humane and less costly stabilization designs, such as speed tables and the raising of intersections.

Sponging. The main way that use permeable paving to reduce rainwater infiltration into the ground, can control rainwater runoff at source. Permeable paving can be used on waterlogged sections, gardens and car parks, while the drainage pipes can be expanded. It also need to increase the number of drainage outlets and check blockages regularly.

Public Transport. Campus bus routes can be designed according to the daily communication routes, which is convenient for teachers and student. Campus buses can be purely electric, in order to reduce pollution. Public bicycle rental points can be centrally located in teaching and residential areas.

Campus Takeaway Management. Improve delivery routes. Campus management department can use the access control system to manage the path of the delivery vehicle after entering the school, to avoid the conflicts; or try to choose the school gate nearest to the delivery address to enter, thus avoiding penetration within the school.

In addition, the delivery will be carried out uniformly by the delivery stations after entering the campus, which can not only alleviate the intense traffic conflicts within the campus, but also become one of the ways for students to work and study [7].

4.3 Optimization of Static Traffic

Size Forecast. The demand for parking on campus can be divided into two parts: daily demand and flexible demand. Daily parking demand forecasts can use the generation rate method based on the nature and size of the building (Eq. 1), while elastic demand forecasts are based on daily demand forecasts multiplied by an elasticity factor [11].

$$y_i = \sum\nolimits_{k=1}^{k} a_i^k X^k \tag{1}$$

In the equation:
y_i is the parking demand (in units) for vehicle type i (motor vehicle, bicycle).
a_i^k is the parking demand generation rate for the i-th vehicle type in the k-th building.
X^k is the architectural (business) scale of the building for building type k.

Composite Layout. It should be focused on making full use of existing resources. For example, a small parking strip can be formed at the side or back of a building The campus parking dynamic guidance system can be built based to provide real-time query service for parking information. It is necessary to mark of non-motorized parking areas to regulate parking, and regularly remove unused bicycles to avoid taking up space. The construction of elevated parking on the ground floor of new buildings and the construction of large centralized underground parking garages are reasonable ways to organize static traffic in a three-dimensional manner.

5 Conclusion

In response to the current problems of high-density campus traffic, this study, based on the concept of green transportation, draws on the neighborhood community model to achieve “safe travel and green environment”. However, this study token the Xinzhuang Campus as an example, has certain limitations for the application in other high-density campuses. Therefore, there is still room for exploring and deepening in practice, and continuous optimization and innovation are needed.

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